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<td><strong>Citation</strong></td>
<td>The 2013 IEEE International Conference of Electron Devices and Solid-State Circuits (EDSSC), Hong Kong, 3-5 June 2013. In Conference Proceedings, 2013, p. 1-2</td>
</tr>
<tr>
<td><strong>Issued Date</strong></td>
<td>2013</td>
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<tr>
<td><strong>URL</strong></td>
<td><a href="http://hdl.handle.net/10722/191664">http://hdl.handle.net/10722/191664</a></td>
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Zn-Doped Zr Oxynitride as Charge-Trapping Layer for Flash Memory Applications

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I. SUMMARY

In this work, we proposed Zn-doped Zr oxynitride (ZrZnON) as a new charge-trapping layer for flash memory applications and investigated its memory characteristics based on the capacitor structure of Al/Al2O3/ZrZnON/SiO2/Si. The high-K dielectric film, ZrON, was used as the control group. The effects of incorporating ZnO in ZrON were studied by comparing the differences of memory properties between the two charge-trapping layers. Measured data showed that the memory device containing ZrZnON had much larger C-V hysteresis window, higher programming/erasing speeds and much better charge retention properties than the one containing ZrON. These improvements should result from charge traps created by ZnO incorporation and deeper quantum wells built by the band-gap alignment of ZrZnON to the SiO2 tunnel layer and Al2O3 blocking layer.

II. MOTIVATION AND RESULTS

To obtain higher programming/erasing speed and better charge retention simultaneously for flash memory applications, near-zero or negative conduction-band offset (NCBO) materials, such as ZnO, GaN and Al1-xGaxN, have been proposed as the charge-trapping layer. It is found that the device with ZrZnON possesses much higher programming speed (5.2 V after 100 μs at +13 V). This should result from the larger conduction-band offset of ZrZnON with respect to the SiO2 tunnel layer and the stronger electron-capture ability of ZrZnON with deeper-level traps. Owing to the negative conduction-band offset of ZnO to the Si substrate, the energy levels of some traps in the ZrZnON film are aligned with or above the valence band of the Si substrate (see Fig. 3). As a result, injected holes during the erasing process can directly recombine with electrons trapped in the ZrZnON film and thus higher erasing speed can be achieved [5]. Fig. 4 shows the charge retention characteristics of both devices. The deep trap levels introduced by the ZnO incorporation and the deep quantum wells built by the band-gap alignment of ZrZnON to the tunnel layer and blocking layer (see Fig. 5) induce much better charge retention property, with a charge retention of 85% after 10 years. Therefore, we believe that high-K dielectrics mixed with suitable NCBO materials, such as ZnO, should be good candidates as charge-trapping layer for flash memory applications.

REFERENCES

Fig. 1 Typical normalized C-V curves of MONOS memory devices containing the ZrON and ZrZnON as charge-trapping layer.

Fig. 2 (a) Program and (b) erase transient characteristics of devices with ZrZnON and ZrON as charge-trapping layer.

Fig. 3 Band diagram of the memory devices under erase state.

Fig. 4 Charge retention properties the devices containing ZrZnON and ZrON.

Fig. 5 Band diagram of the memory devices under retention state.